**Title:** Making “sense” out of surface area to volume relationships

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**Abstract:**

Using a multimodal approach, students will explore the non-linear aspect of the surface area to volume relationship in a general biology course.  Using their senses of taste and/or sight with different size candies that are coated (i.e. Reese’s Peanut Butter cups), student will determine how smaller cells and larger cells differ in these relationships.  Students will identify the major ingredients as representing either surface area or volume, and identify their preference for small or large candies based on their ingredient preference.   In small groups, small and large circular cell areas and volumes will be calculated and relationships will be established.  Cellular structures related to surface area (membrane) and the cell volumes (organelles) will be reviewed as well as the importance of being small.  Concepts of multicellularity will be discussed. Examples along the biological hierarchy are provided and the relationship between structure and function will be discussed.

**Pedagogical Focus:** Active Learning, Collaboration, Data-centric

**Audience**: Grades 9-12, Undergraduate: Lower Division

**Learning Objectives:**

* Identify cellular structures that comprise the surface and volume of cells.
* Calculate surface area to volume ratios for large and small spheres.
* Apply surface area to volume relationships to justify why cells have an upper limit in size.
* Explain the advantages of an organism being composed of multiple small cells versus a giant single cell.

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| Learning Objective | Resources | Assessment |
| Identify cellular structures that comprise the surface and volume of cells. | 1. Pre-class assigned reading: ex: Campbell’s Biology Ch. 6 *All About Cells*
2. Lecture notes: Introduction to the Cell
 | 1. Check in polling (formative)
2. Quiz (summative)
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| Calculate surface area to volume ratios for large and small spheres. | 1. Lecture notes
2. Collaborative activity: Making Sense out of Surface Area to Volume Ratios
 | 1. Collaborative activity worksheet Part II (formative)
2. Quiz (summative)
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| Apply surface area to volume relationships to justify why cells have an upper limit in size. | 1. Collaborative activity
 | 1. Collaborative activity worksheet Part II (formative)
2. Quiz (summative)
 |
| Explain the advantages of an organism being composed of multiple small cells versus a giant single cell. | 1. Collaborative activity
 | 1. Collaborative activity worksheet Part II (formative)
2. Quiz (summative)
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**Timeframe:**

This module occupies portions of two class meetings (approximately 35 minutes total). This activity has been used successfully in first year introductory biology class for science majors, which has the emphasis on cellular biology. This activity has not been used as a standalone lesson and has been used to augment the understanding of the importance of the cellular membrane as well as introduce a fundamental surface area to volume relationship that will be discussed throughout their biology courses.

**List of Materials:**

1. Lecture Slides: Introduction to the Cell.pptx
2. Collaborative Activity Worksheet: Making Sense out of Surface Area to Volume Ratios
3. Different size candies that are coated. Suggestion Reese’s Peanut Butter cups in mini, miniature (snack), regular, and big cup sizes. Note that these contain peanuts for those with allergies.
4. Formative Assessment (individual or group): SA:V Quiz.docx
5. Optional: models of cells

**Procedure for Instructors**

*Prior to first class meeting covering this lesson*

* Assign students reading to augment the lesson on introduction to cells. For example, Chapter 6 in the Campbell’s Biology book is “A Tour of the Cell”.
* Purchase different size candies that are coated; suggestion Reese’s Peanut Butter cups in mini, miniature (snack), regular, and big cup sizes.
* Arrange candies in groups according to so that each group takes up a similar area. 1 big cup, 2 regular cups, 4 snack cups, and 10 mini cups. If using as a demonstration, you only need 1 arrangement. If providing to groups, you need one arrangement per group. You can offer a plastic knife to allow students to cut open the candy to examine the contents.





*First Class Meeting (based on a 75 minute class period)*

* Begin with powerpoint lecture “Introduction to Cells”, pausing after surface area to volume relationships. This should review over their reading and should take 20 minutes.
* Begin demonstration of different size candies that are coated\* (i.e. Reese’s Peanut Butter cups). Ask students if they enjoy eating the candy. For those that enjoy eating the candy, ask which part they enjoy the most – the coating or the filling. Ask them if they have a preference for the smaller sizes or larger sizes. Does one of them taste better for them and why does it taste better. Undoubtedly, one student who enjoys the filling will have a preference for larger size candies and another will enjoy the coating will have a preference for smaller candies. For those that do not enjoy the candy, you can ask them what type food that they enjoy that is coated and/or has a filling and ask them the same suite of questions. Guide them through the questions in Part I of the activity handout. End Part I by bringing the class together and asking if large or small coated candies have more coating relative to filling. Engage them to use their sense of sight and taste (optional). Can they see and taste more filling in the large cups? Can they see and taste more coating in the smaller cups? What does the coating and filling represent for a cell? How can we quantify the amount of coating and filling relative to each other (surface area:volume)? This should take 6-10 minutes.

\* Check in with students to determine if there are any food allergies and the severity of them.

* Guide them through the questions in Part II of the activity handout. Pending the quantitative abilities of your students, this should take 5-15 minutes.
* Complete the lesson by reverting back to the powerpoint lecture “Introduction to Cells”, covering the evolution of multicellularity and other ways for cells to increase their surface area relative to volume. Providing examples of increased surface area to volume structures along the biological hierarchy is beneficial at introducing topics that will be seen in the class. This should take about 10 minutes.
* The remainder of the class period (about 20-34 minutes) is spend reviewing over the structures and functions of organelles that were part of their pre-class reading.
* An optional take home assignment can be given to students: Provide an example of an organism that has a structure with a high surface area. What in having this structure, what is the benefit (function)?

*Second Class Meeting (based on a 75 minute class period)*

* Begin by revisiting the concept by asking students to complete a closed note quiz (SA:V Quiz.docx). You have the option to assess them by groups or individually and to treat it as a low stakes (formative) or higher stakes (summative) assignment. This should take 5 minutes.
* Ask students to share their answers. Review over answers to alleviate misconceptions. To reaffirm students who might still be having trouble, I like to have a few sizes of different size candles on hand and ask them if I like chocolate more than peanut butter, which size should I buy? I also like to pass out individually wrapped candies as rewards for answering questions. This should take 5 minutes.